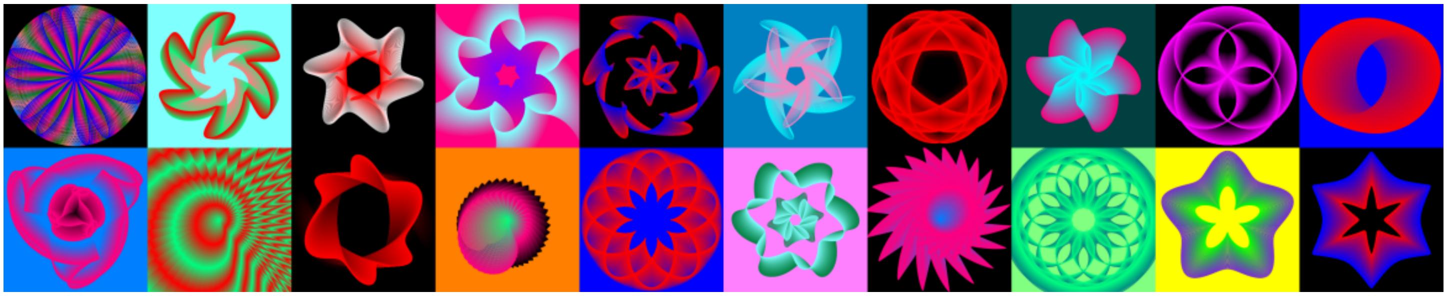
Basic tutorial for Magic Designer emulator software v.1.3 (2009 version)

This tutorial has been tailored to the Windows version of the emulator. Download links are listed on the Magic Designer website at http://akatz712com/.
Links to online versions of the emulator are also available on that website. The Magic Designer emulator was created and developed by Andrew S. Katz.
Original instruction sheets for the mechanical versions of the Magic Designer and of the Hoot Nanny No.2 can be found here and here.

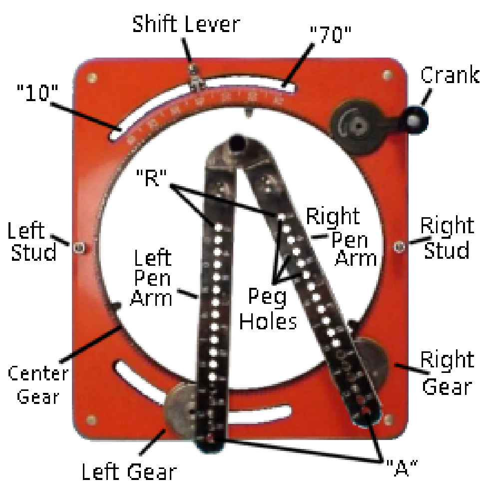


Presented free of any charge or obligation, the Magic Designer emulator is designed to be run as a stand-alone application for Windows, as well as on other platforms by means of supported Web browsers. This latest available version of the emulator evolved from Andrew Katz's initial programming efforts about 35 years ago. The emulator precisely models the mechanical version of the Magic Designer, but it also incorporates settings that allow for the creation of incredible design patterns far surpassing those possible for the physical device.

Originally called the “Hoot Nanny”, the mechanical Magic Designer was invented in 1929 by Howard Bevan Jones of Chicago, Illinois. Mr. Jones produced and marketed the Hoot Nanny until selling the manufacturing rights to the Northern Signal Company of Saukville, Wisconsin. Renamed the “Magic Designer”, the device was marketed for another 50 years or so as a “toy” for children, although it also had any number of adult users.

Since the emulator is modeled on the mechanical device, a familiarity with the original will help the new User. The Magic Designer was solidly constructed on a steel base supported by rubber feet. Mounted on the base was a 6-inch Center Gear that could be rotated by turning a small, geared Crank. Special paper “discs” were placed on the Center Gear, each disc having three small notches that fitted securely under three small tabs on the Gear.

The Center Gear was meshed with two planetary, 1-inch Gears. The Right Gear was fixed in place, but the Left Gear could be moved through a 60-degree arc by means of the Shift Lever, connected by a linkage beneath the base. The Shift Lever could be positioned at any of 60 small notches in the base, indexed from “10” to “70”. The base also held two fixed “Circle” Studs, each offset ¼-inch from the edge of the Center Gear.



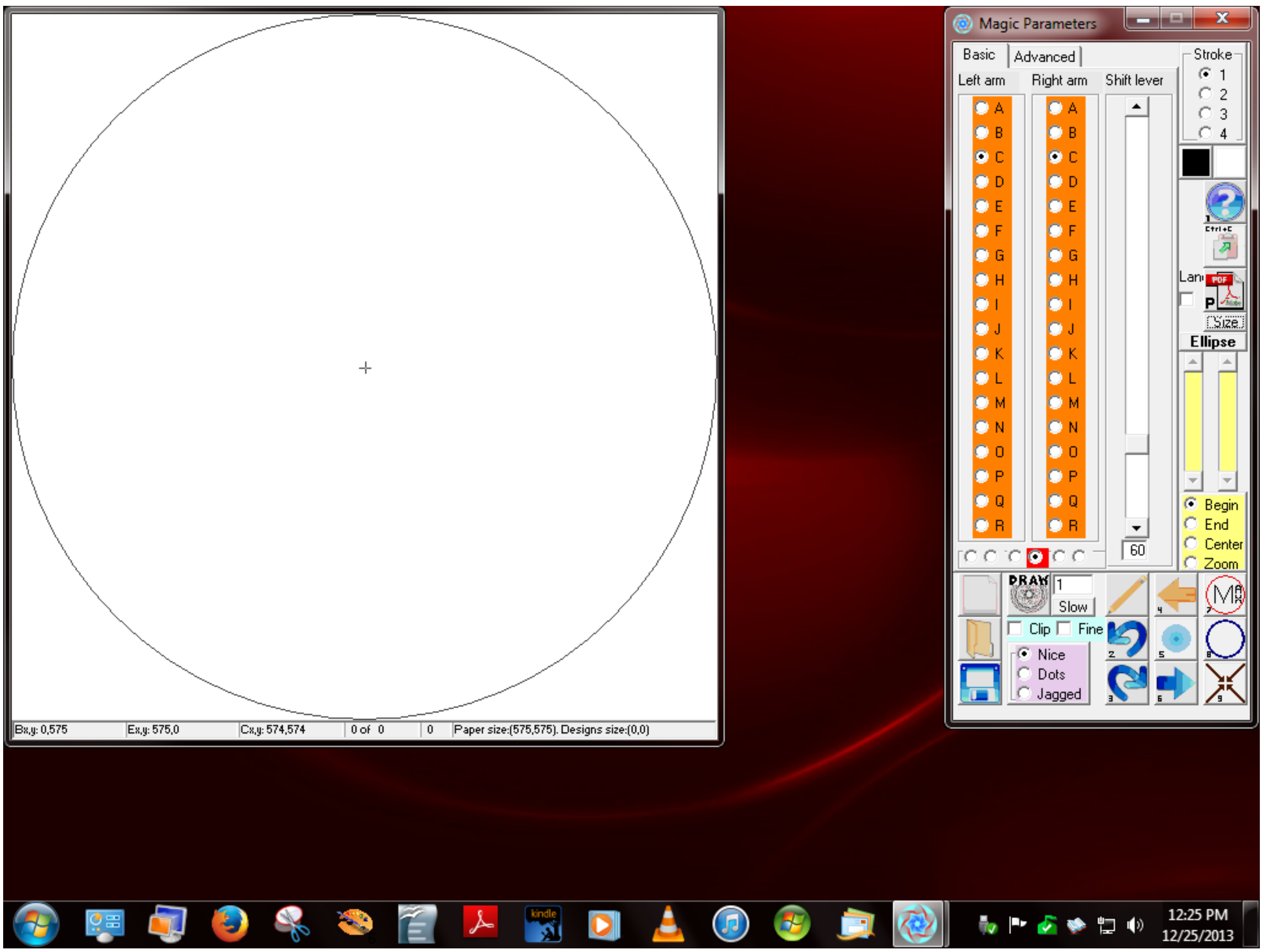
On each of the planetary Gears and on each of the Studs, a small Peg protruded. The Peg Holes of the two Pen Arms, lettered “A” through “R”, could be fitted onto any of these Pegs. At certain times the ends of the Pen Arms could interfere with the Crank, so the Crank could be rotated backwards to three spring-loaded “stops”, while the user held the Center Gear firmly in place, allowing the Crank to clear the Pen Arms.

On the 1-inch planetary Gears, the Pegs were offset 1/8-inch from the edges of the Gears. Thus when the planetary Gears rotated, their Gear Pegs described Gear Peg Circles with diameters of ¾-inches.

In a vertical holder at their hinged junction, the Pen Arms firmly held a pen or a pencil that drew a pattern on the paper disc as the Crank was turned. The Pen Arms had circular depressions near the pen holder, where the User would place fingertips to hold the pen or pencil securely against the paper. The Pen Arms could be arranged in any of six Placements: (1) Left Stud/Left Gear; (2) Left Stud/Right Gear; (3) Left Stud/Right Stud; (4) Left Gear/Right Gear (as pictured above); (5) Left Gear/Right Stud; and (6) Right Gear/Right Stud.

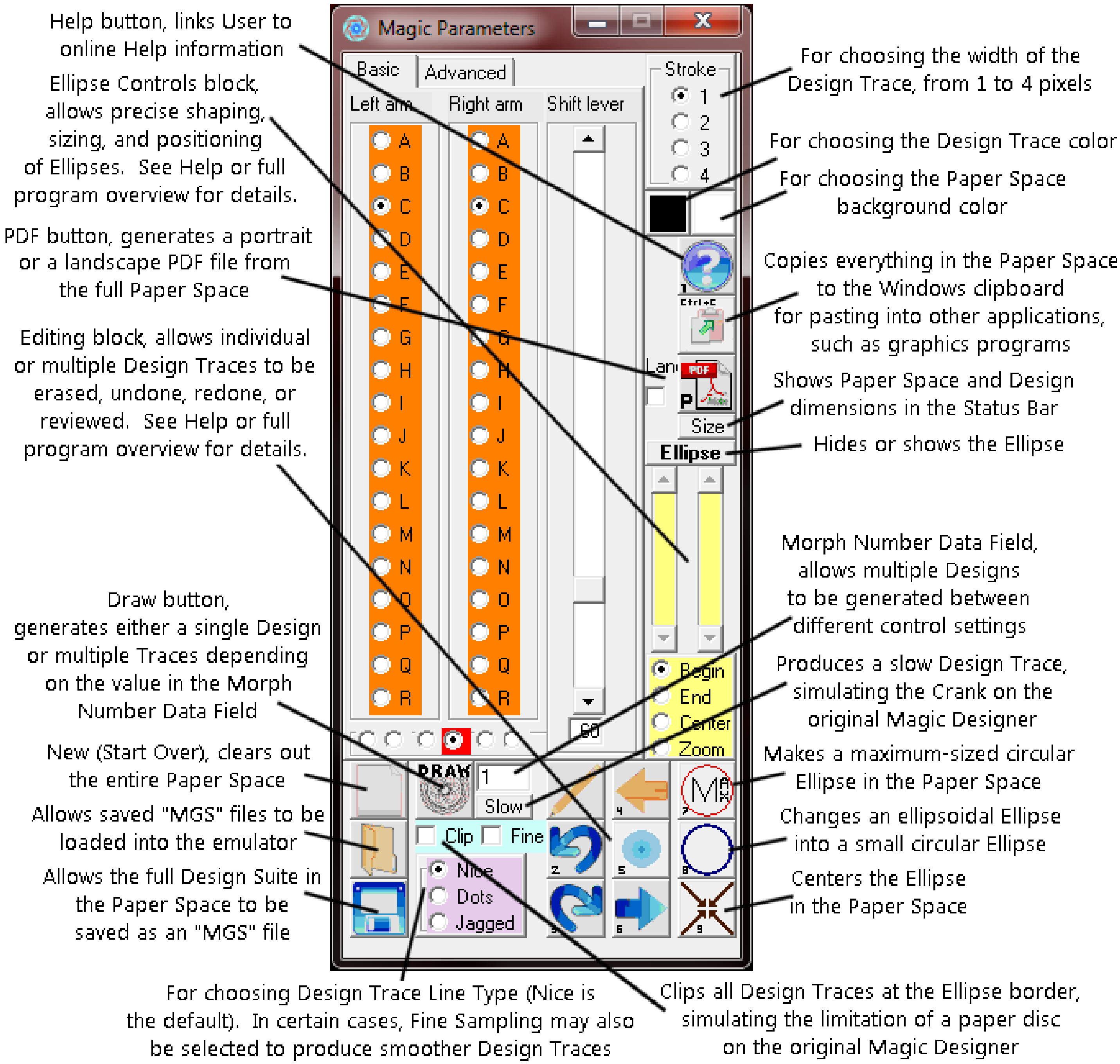
From simple circles, when both Pen Arms were placed on the Circle Studs, to more complex designs using the other five Pen Arm Placements with various Peg Hole selections and Shift Lever settings, the original mechanical Magic Designer allowed perhaps literally millions of different patterns to be drawn, but the emulator version of the Magic Designer has been designed to *definitely* allow literally millions more. This tutorial will describe many of the main features of the stand-alone Windows version of the emulator, and most of the concepts presented here will apply to the Web-based versions as well. However, the stand-alone Windows version does have some innovative features not yet included in the Web-based versions.

The Magic Designer emulator opens with the Magic Paper window at the top-left of the screen and with the Magic Parameters window at the top-right, as shown below. To move the Magic Paper window, right-click anywhere inside the window and perform the following keyboard sequence: in order, push and hold down Alt+Space+m, then release and hit any arrow key. Use the arrow keys or move your mouse or scroll your touchpad to reposition the Magic Paper window, and left-click to release it. To move the Magic Parameters window, drag its title bar. To re-size the Magic Paper window, drag any of its corners or borders.



Examining the Basic Tab of the Magic Parameters window, you should see many obvious correlations to the physical Magic Designer. The Left and Right Pen Arms have the same lettered Peg Holes from “A” to “R”, and the Shift Lever is adjustable from “10” to “70”. Beneath the Pen Arms you will see a row of six Pen Arm Placement bullets. These correspond respectively to the six Pen Arm Placements mentioned on the previous page. The fourth bullet with the red frame is the default Placement of Left Gear/Right Gear, arguably the most-used Pen Arms Placement.

Most of the less obvious functions of the Basic Tab are briefly explained in the illustration below.



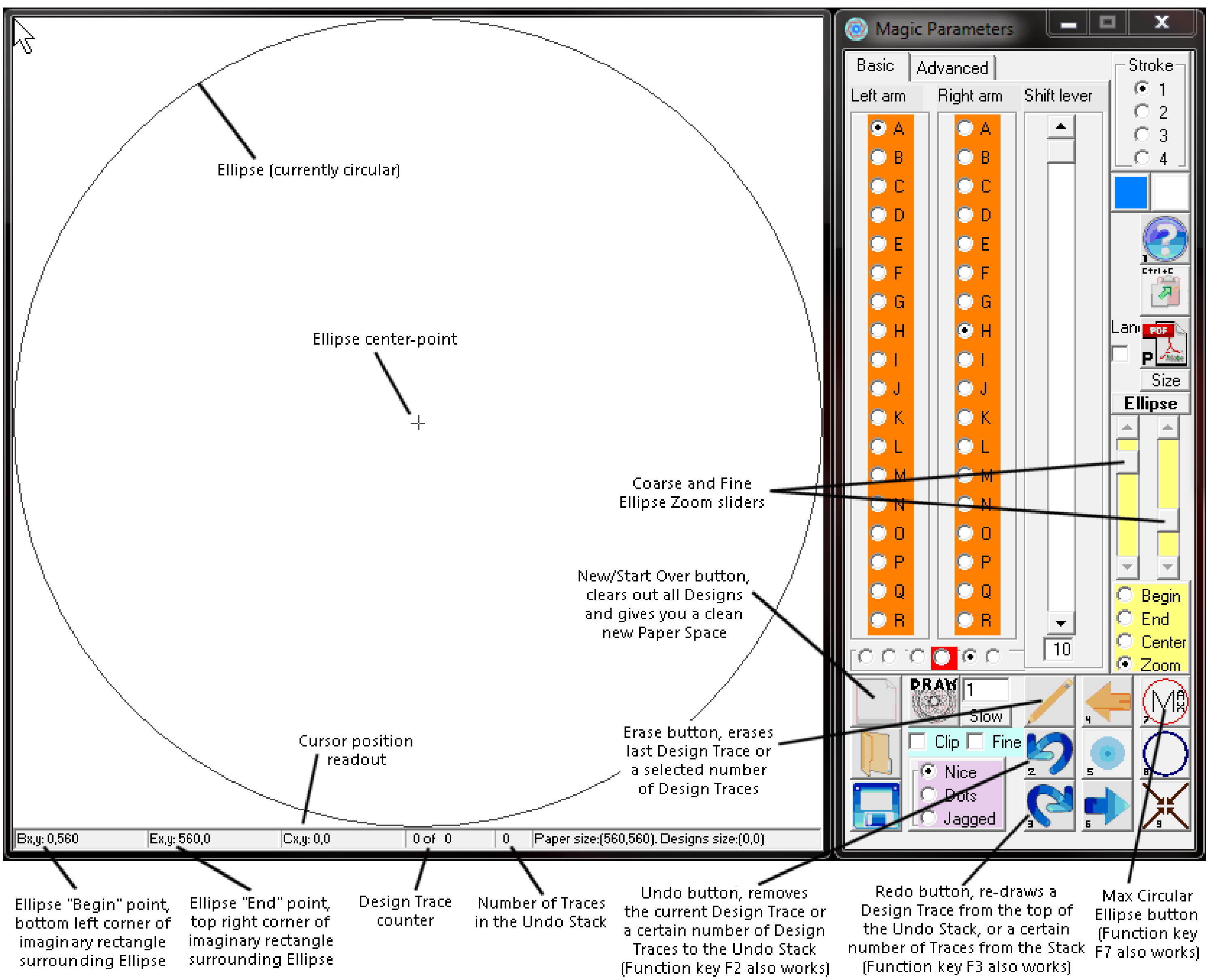
Before any in-depth examination of the basic and advanced features of the emulator, the beginning User will probably benefit from generating some actual Magic Designs. If you, the User, have been experimenting on your own up to this point, that's great. One of the best ways to learn about the capabilities of the emulator is simply to try things and see what happens. However, if you, the User, want to proceed with this Tutorial, we will need to be on the same page, so to speak.

Click the New/Start Over button, and position the Magic Paper window and the Magic Parameters window next to each other on your screen. Drag the upper and lower borders of the Paper window until it is the same height as the Parameters window. Then drag the sides of the Paper window until it is roughly square. Alternately click the Size button and adjust the borders of the Paper window until the message in the Status Bar at the bottom

right of the window says “Paper size:(560,560)”. Click the “Max Circle” button, the third button up from the bottom right on the Basic Tab. If no Ellipse is showing in the Paper Space, click the “Ellipse” button to reveal it. Your Paper window should look just like the one shown further below on this page.

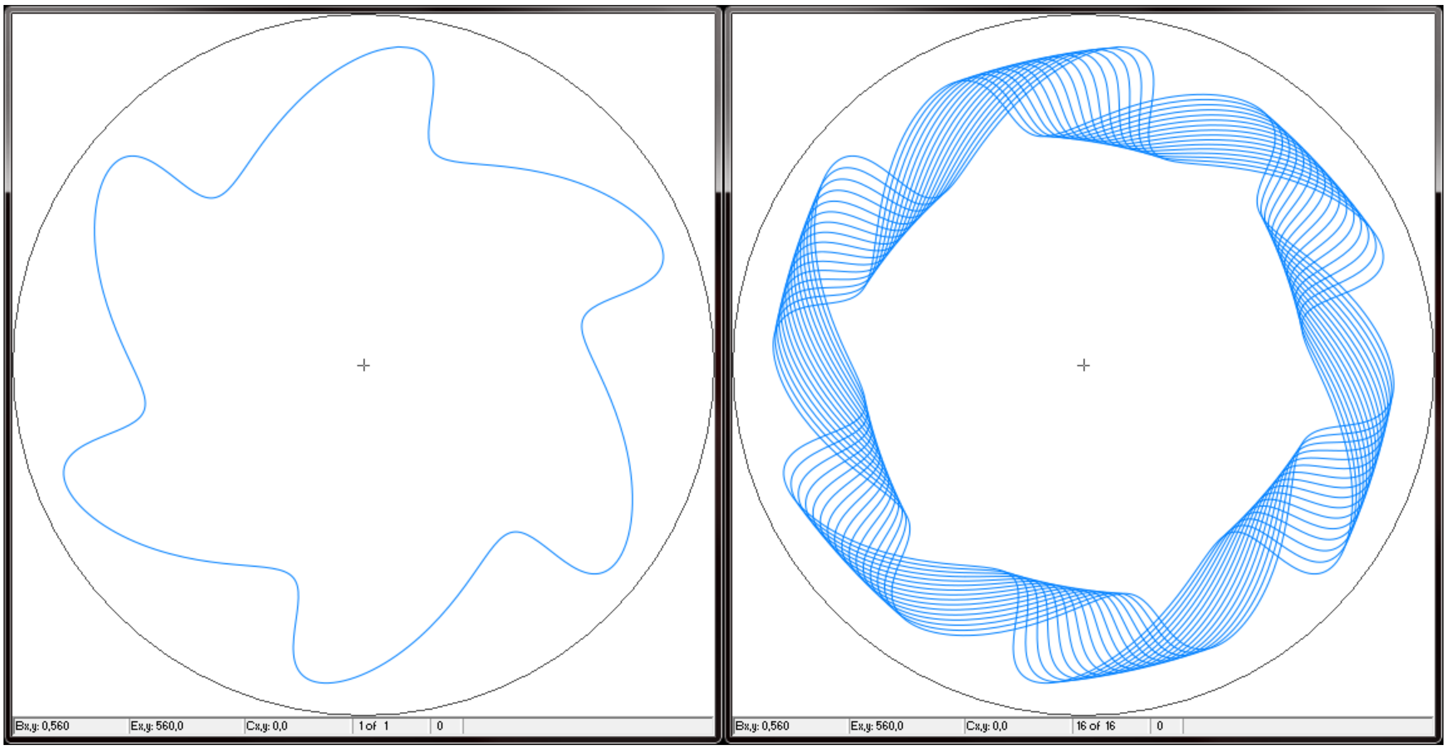
Notice that when your cursor is positioned at the top left corner of the Paper Space, the “Cx,y” Cursor field in the Status Bar reads “0,0”. Everything within the Paper Space is measured from this “origin” point in terms of pixels, “x” for horizontal pixels and “y” for vertical pixels. The Cursor readout allows you to precisely size and position any Ellipse within the Paper Space, to its exact pixel dimensions and to its exact pixel center-point. “Pixel” is a rough portmanteau word for “picture element”, the smallest image element that can be manipulated. Each pixel in a Magic Design is a tiny square of a single color, although that color can be any one of millions.

Move the cursor to the center-point of the Ellipse and observe the values in the Cursor readout, then move the cursor to the bottom right of the Paper Space. Notice that the final, 560th horizontal and vertical pixels can't be “resolved” in the readout, but only the 559th pixels. This is because the cursor will technically be outside the Paper Space at the edges of the 560th pixels. Now make all of the settings in your Magic Parameters window Basic Tab match those shown at the right in the image below.



We'll begin by drawing some Design Traces exactly like those that could be produced by the original Magic Designer, and then we'll make changes to illustrate some of the ways that the emulator goes beyond the original. Click the Slow button, to get an impression of what it was like to “crank” out a Design on the mechanical Magic Designer. The Trace generated by the Slow button is only a preview that will not remain in the Paper Space. Now click the Draw button. Your Paper Space should have the Design Trace depicted at the left below. Notice the Design Trace Counter readout in the Status Bar. Click the Erase button. The Design Trace is gone and the Trace Counter returns to “0”. Click the Draw button to get the Design Trace back. Now click the Undo button and notice the readouts. Now click the Redo button. Again you should have the Trace shown to the left below.

At the bottom of the Shift Lever, click the “down” arrow twice (don't use the keyboard arrow keys, because of a program bug not yet resolved). The Shift Lever readout below the button should read “12”. Click the Draw button. Continue to increment the Shift Lever in 2-step increments, drawing a Trace at each increment, until you reach a readout of “40”. Your Paper Space should look just like the one shown to the right below, and your Design Trace counter should read “16 of 16”.



In the Morph Number Data Field, just to the right of the Draw button, enter the number “15” and click Undo. You should be back to the single Trace shown at the left above. Again enter “15” in the field and click Redo. You should be back to the Design Suite on the right. Undo 15 Traces once more, to the single Trace on the left. Now enter “50” in the Morph Number Field, and click Draw. The emulator calculates 50 increments to “morph” between the Shift Lever settings of 10 and 40. Now enter “50” in the field and click Undo, back to the single Design Trace on the left.

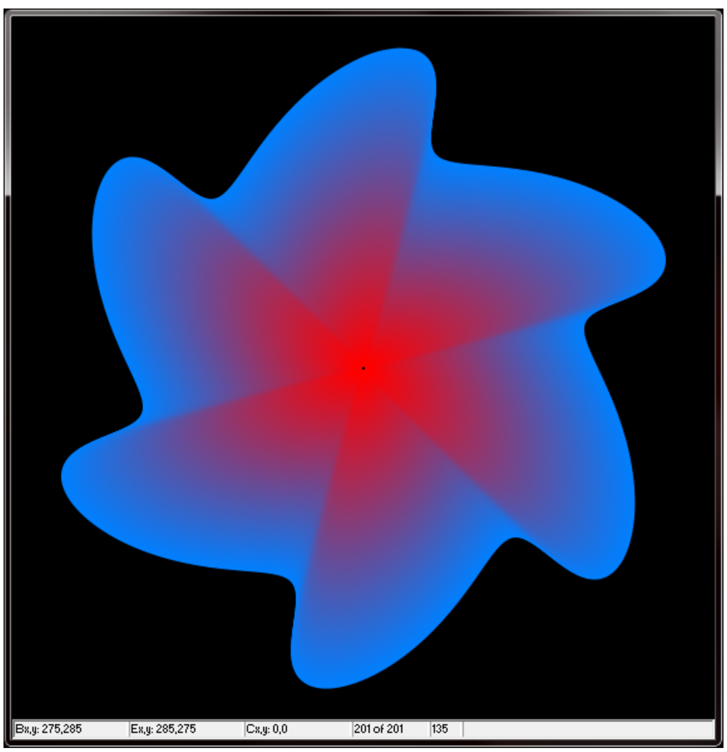
In the Shift Lever readout, enter “10”. The slider button will snap back up to the top. Click in the white space below the slider button. The button will increment by 10 counts for each click. Place your cursor on the slider button and move it up and down the slide, observing the readout. Now enter “40” in the readout once again.

Change the Design Trace color to red. Enter “50” in the Morph Number Field and click Draw. The emulator will simultaneously morph between different Shift Lever settings and different Design Trace colors. Now change the Paper Space background color a few times. Try purple and dark green and black. Go back to white.

Enter “50” in the Morph Number Field and click Undo. You should be back to your single blue trace on a white background. Change the Design Trace color back to blue, return the Shift Lever to “10”, and change the Line Width (Stroke) to “4”. Click Undo once more to clear your single blue Design Trace, and then click Draw. Now your single blue Design Trace will be much wider.

Change the Line Type to Dots, then to Jagged, and finally back to Nice. Now change the Stroke back to “1”, and change the Design Trace color to white. Click Draw to obtain a nice “ribbon” effect. Note that you can repeat a sequence of wide Traces at a narrower Stroke with a different color, giving each Trace in the Suite the ribbon look. While you have the ribbon trace try Dots and Jagged again, ending back at Nice. Click Undo to remove the white ribbon. You should be back to your single wide blue Trace. Return Stroke width to “4”.

Now push and hold down the keyboard “up” arrow key. If you properly selected the “Zoom” bullet at the start of this exercise, the Ellipse should steadily shrink in size. Now release the arrow key and move the Zoom sliders in the Ellipse Controls to notice their effects on Ellipse size. Click and hold the arrow buttons at the ends of the slides as well. They offer finer zoom increments. Zoom the Ellipse to about half its original diameter. Change the Design Trace color to red and click Draw. You will see that Designs proportionally scale in size along with their Ellipses. Click Undo to remove the Red Design Trace, and zoom the Ellipse down to its minimum possible size. Now enter “200” in the Morph Number Data Field and click Draw. Change the background color to black and hide the Ellipse. You should have the Paper Space depicted to the left below.



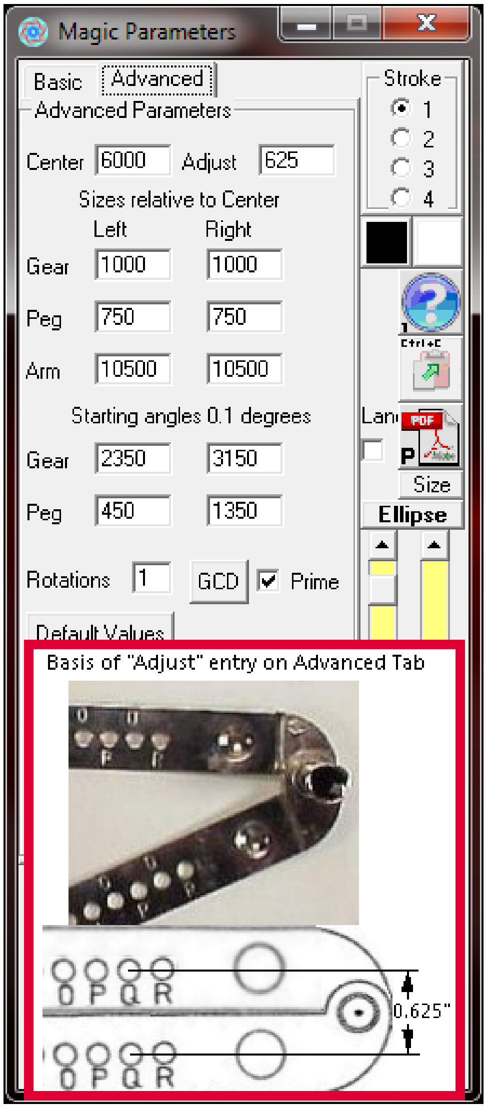
The emulator allows you to morph between different starting and ending Design Trace sizes, Design Trace shapes, Design Trace center-point positions, Design Trace colors, Shift Lever settings, and Pen Arm Peg Hole positions, or any combination of these, at linear increments according to the value entered in the Morph Number Data Field. The emulator will not always be able to produce the number of Traces entered in the Morph Number Data Field, but the Status Bar will report the actual number of Traces generated.

The emulator does *not* allow morphs between different starting and ending Line Widths (Stroke), different Pen Arm Placements, or different Design “Sidedness” settings (or gear ratios, to be explained shortly). Attempts to perform such morphs will return an error message in the Status Bar.

Morphing is obviously a powerful feature that lets the emulator leapfrog the physical Magic Designer. But there are still more advantages to the emulator.

The original Magic Designer had a 6-inch diameter Center Gear and 1-inch diameter planetary Gears. Except for plain circles, this fixed, 6-to-1 gear ratio could produce nothing but six-“sided” Designs. Six-sidedness is a pleasant property often found in Nature, as represented in many things from certain atomic structures and rock formations through honeycombs and snowflakes, but patterns and designs of other sidedness can be equally pleasing. The emulator allows the User to adjust gear ratios to obtain Design Traces with any number of sides, although a dozen or so is probably a reasonable limit. For Magic Designs, as in other things, less is often more.

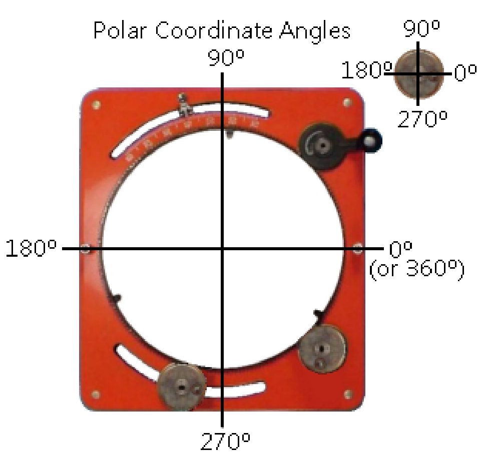
Click the New/Start Over button and select the fourth Pen Arms Placement bullet, the one with the red frame. Now click the Advanced Tab. This will produce an overlay, containing several data fields, that covers the Pen Arms, Shift Lever, and Pen Arms Placement bullets on the Basic Tab, as shown to the left below.



The Advanced Tab displays default values in all of its data fields for Pen Arms Placement "4", but these values can be changed as desired. Recall that in this Pen Arms Placement setting, the Left and Right Pen Arms are placed, respectively, on the Left and Right Gears. In order to understand the default values in the data fields of the "fourth position" Advanced Tab, we will refer back to the properties discussed for the physical Magic Designer.

The original MD had a 6-inch diameter Center Gear. The Center data field on the Advanced Tab shows this as 6000 inches, with an implied decimal point to the right of the "6". It follows from the three "zeroes" after the decimal point that the emulator calculates Gear diameters to the nearest thousandth of an inch. Although it can be changed, the Adjust field is usually set to 0.625 inches, a correction factor due to the Peg Holes of the mechanical Pen Arms not being perfectly in-line with their pen holder. Note further that the 1-inch diameters of the Left and Right Gears are listed as 1000 (1.000), and that their respective Gear Peg Circle diameters of ¾-inches are listed as 750 (0.750).

Pen Arm Lengths are also listed in inches to the nearest thousandth of an inch. On the physical Magic Designer, Pen Arms can be pegged at "A", for their longest lengths from the Peg Hole to the pen or pencil point, through "R", for their shortest lengths. At "A" on the physical Magic Designer, the actual length is 5.750 inches, and at "R" the actual length is 1.500 inches. Due to an obscure advantage for the emulator's internal calculations, the values listed for Pen Arm Lengths on the Advanced Tab are exactly double those of the physical Magic Designer. Since both Pen Arms are currently pegged at "C", which on the mechanical MD corresponds to a physical length of 5.250 inches, the data field length values for both Pen Arms are 10500 (10.500).



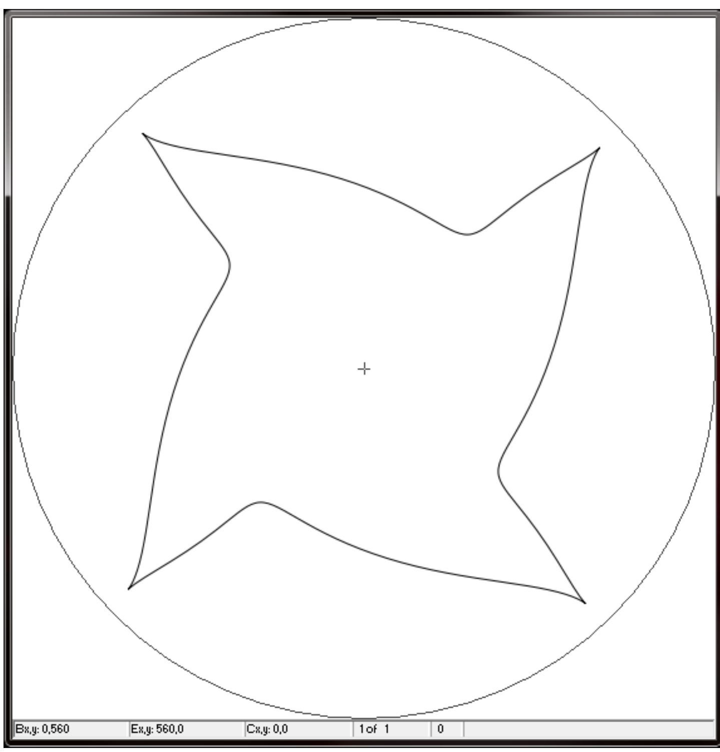
Default angles for both the planetary Gear centers and for their Gear Pegs are also shown on Advanced Tab 4, to the nearest tenth of a degree. The angles for the planetary Gear *centers* have polar coordinate values as illustrated to the left. An imaginary line from the center of the Center Gear extends to the right, or east, through the Right Stud. If pivoted on the center point and rotated counter-clockwise, this line would then produce the angles of 90º, 180º, and 270º as shown, all the way to 360º, which is also the starting point. The planetary Gear center angles are defined this way, but their Gear *Peg* angles are defined from the polar coordinates of the Gears themselves, as shown in the small offset diagram.

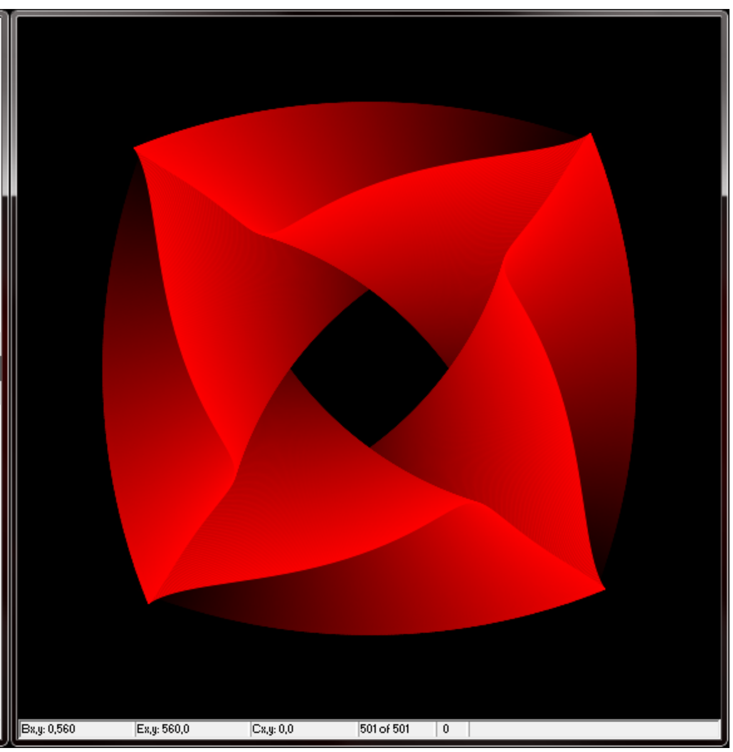
With this new information, how can we generate, say, a 3-sided Magic Design rather than a 6-sided one? Change one or both of the planetary Gear values from 1000 to 2000. Now the gear ratio between the Center Gear and at least one of the planetary Gears will be 3-to-1 instead of 6-to-1. Click Draw, and observe the 3-

sided figure generated. Click the New button to clear the Paper Space. Now enter 4000 for both planetary Gears, and click Draw. The Design Trace will not be complete. Click the New button to clear the Paper Space, and now click the GCD button. This "greatest common divisor" button tells the emulator to calculate whether more than one rotation of the Center Gear will be necessary in order for a complete Design Trace to be generated. In this case, 2 revolutions will be needed. Click Draw. You will have a completed, 3-sided figure that required 2 rotations of the Center Gear. Click the Default button, and then return to the Advanced Tab. All of the data fields will once again have their default values. Click the New button to clear the Paper Space.

In the Advanced Tab fields, enter "1500" into the fields for both the planetary Gear diameters and for the Gear Peg Circle diameters. That's 1500 in all four fields. The 1500 value equals 1½ inches, for a 4-to-1 gear ratio, which will produce a 4-sided Design. In this case, we have made the Gear Peg Circle diameters equal to the diameters of the Gears. We could, if we so desired, make the Gear Peg Circle diameters *larger* than the Gear diameters, as though the Pegs extended outward from the Gears on little arms or "planks". This is yet another way in which the emulator surpasses the real-world limitations of the original Magic Designer.

Now go to the Basic Tab. For the Left Pen Arm choose Peg Hole "B", and for the Right Pen Arm choose Peg Hole "I". Adjust the Shift Lever to "70" and click the Draw button to obtain the Design Trace shown to the left below. Now reverse the positions of the Pen Arms. That is, for the Left Pen Arm choose Peg Hole "I", and for the Right Pen Arm choose Peg Hole "B". Change the Design Trace color to red. Enter "500" into the Morph Value Data Field and click the Draw button. Now hide the Ellipse and change the background color to black. Your Magic Design should be identical to the one shown at the right below.

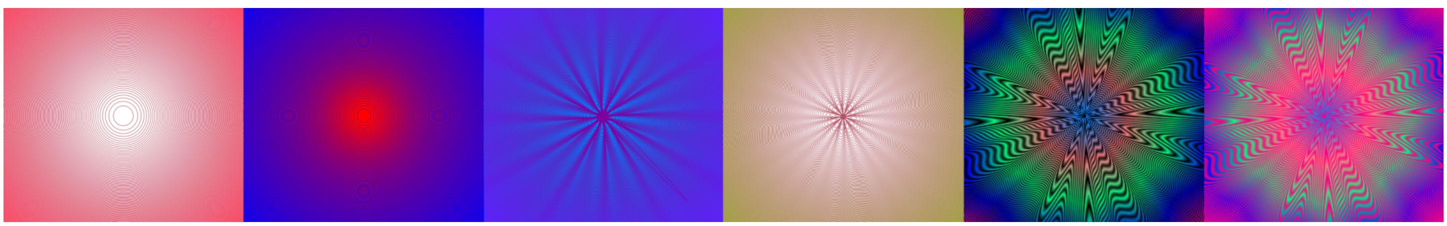




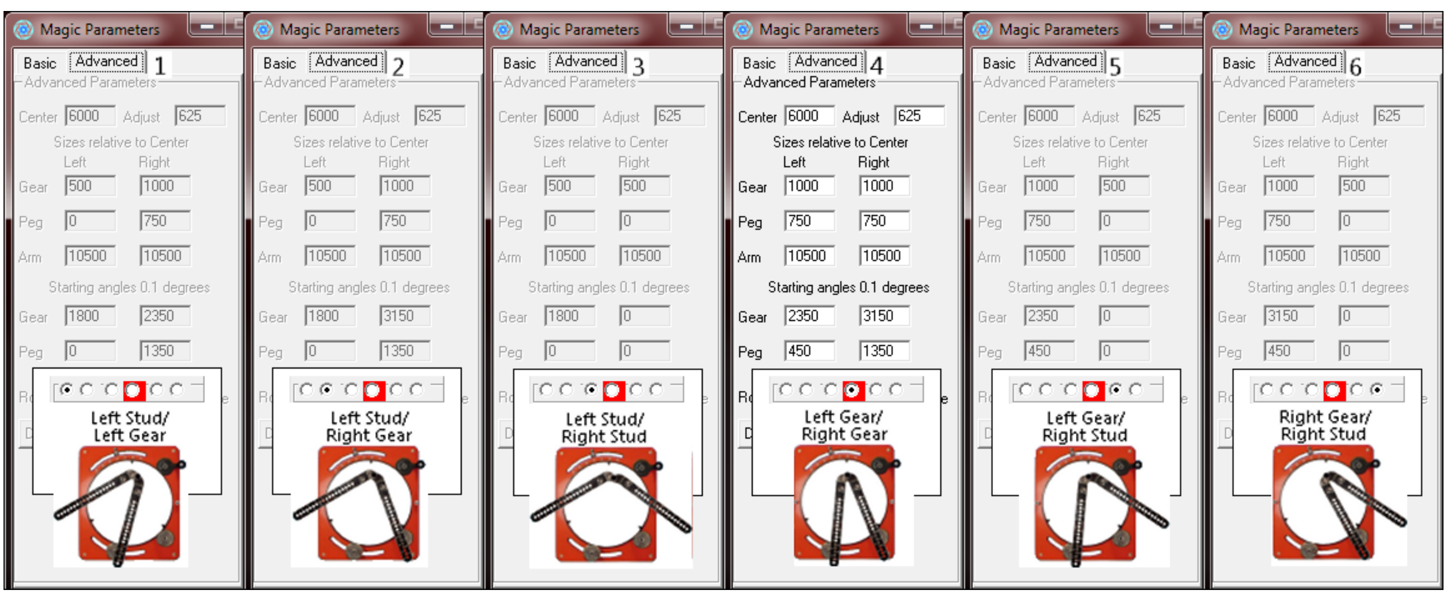
Now click the New button to clear the Paper Space again, and go to the Advanced Tab to click the Default Values button. On the Basic Tab, click the third Pen Arms Placement button. Recall that this is the Left Stud/Right Stud setting, for drawing circles. Now go to the Advanced Tab. All of the data fields are grayed out. Currently the only Pen Arms Placement setting that yields an Advanced Tab with active, changeable data fields is the fourth Placement, Left Gear/Right Gear, with which we produced our last Design Suite. However, the default values in the grayed out data fields are still correct, and will be correct, for each Pen Arms Placement.

It is instructive to look at the double Circle Studs configuration because of the way in which the emulator models the Studs. If you look at the grayed out fields you will see that the emulator treats the Studs as though they too, are planetary Gears. However, a ½-inch diameter Gear, with a Peg at its center describing a “zero-diameter” Peg Circle, is functionally the same as a fixed Stud, ¼ inch from the edge of the Center Gear, just as will be found on the original Magic Designer. Thus the emulator can treat the Studs as though they are simply another kind of Gear, simplifying internal calculations. If you take another look at the polar coordinate angles diagram previously presented, you will note that the Right Stud is at 0º and that the Left Stud is at 180º. If you then look at the grayed out fields on the Advanced Tab which represent these “Gear center” angles, you will see that they are correct for the Studs, and that the 0º angles listed for the Pegs are also correct. So the polar angles of the Studs and their Pegs are also well-modeled when the emulator considers the Studs to be “Gears”.

Before leaving Advanced Tab “3”, understand that all of its grayed out data field values can be manually entered into the active, Advanced Tab “4” fields, forcing Advanced Tab 4 to behave as though it were Advanced Tab 3. This can be done for any of the Advanced Tabs with grayed out fields. One big advantage of going to the trouble to do this is that Designs of different sidedness can then be generated for more Pen Arms Placements than just number “4”. For Tab “3” there is another advantage. Limited to the Basic Tab alone, Placement “3” circles can be morphed in close increments to different diameters and colors, producing some striking moiré patterns, but when the Advanced Tab can be brought into play as well, small “wobbles” of the Stud “Gears” and “Pegs” can be introduced for even more interesting visual effects. Line widths and Trace spacings will also play a role, as will screen properties and display size. The image below illustrates some of the possibilities.

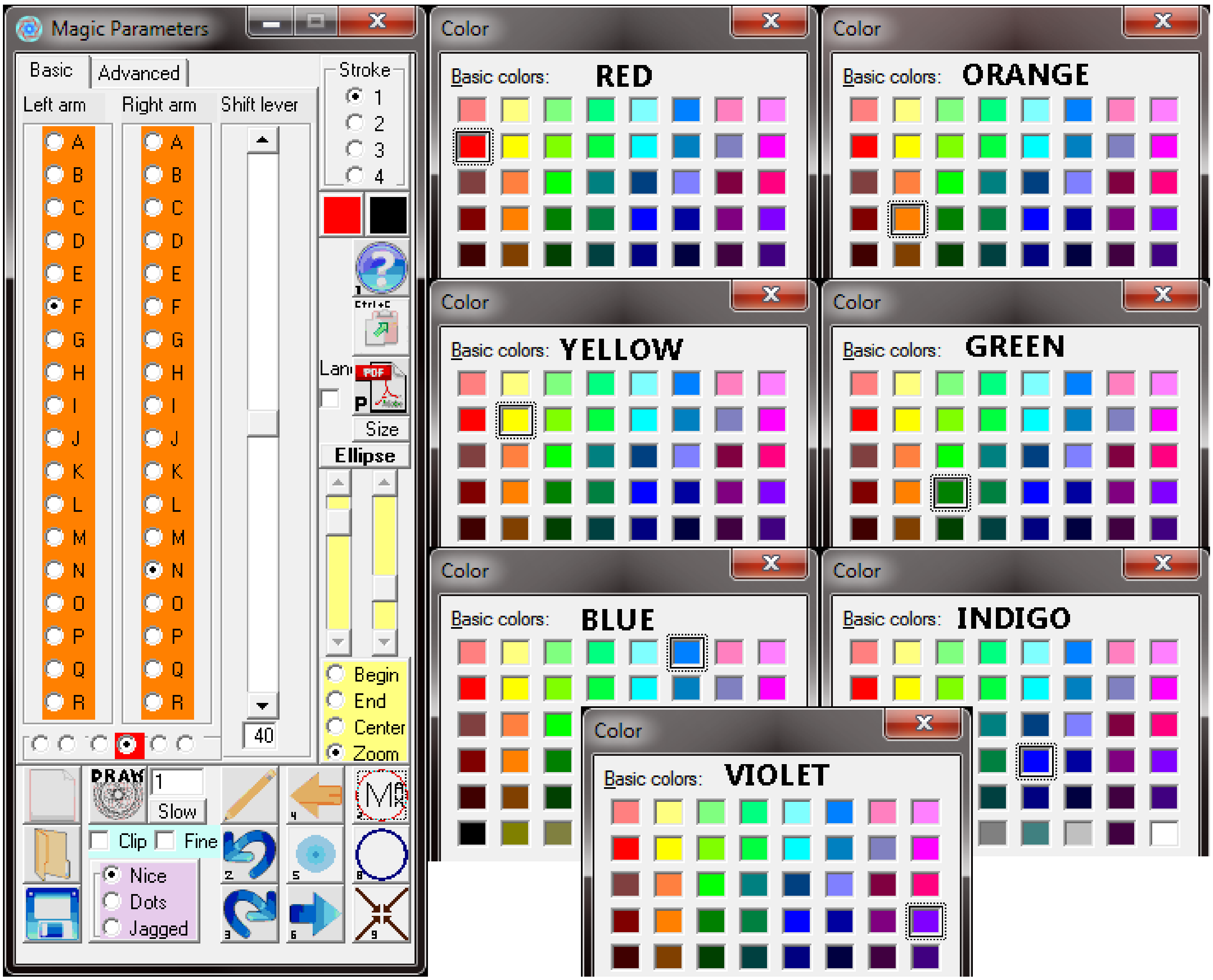


Below is a “cheat sheet” for all of the Advanced Tabs, which you can use to force Advanced Tab 4 to simulate the default values of any other Advanced Tab. Then you can introduce different gear ratios and other changes.



If you are currently looking at Advanced Tab “4”, click the “Default Values” button to ensure that all data fields are reset. If you are currently contemplating the grayed out values of an Advanced Tab other than “4”, go to the Basic Tab and click the fourth Pen Arms Placement bullet, the one with the red frame.

On the Basic Tab, the Pen Arms and the Shift Lever will be at their default settings. You should still have a square Paper Space of 560 x 560 pixels, which you can verify by clicking the “Size” button and noting the message in the Status Bar at the bottom of the Magic Paper window. Change the Left Pen Arm Peg Hole to “F”, change the Right Pen Arm Peg Hole to “N”, and adjust the Shift Lever to “40”. Click the “New/Start Over” button, and then click the Max Circle Ellipse button. Ensure that your Line Type is “Nice”, with “Clip” and “Fine” not checked. Be certain that “Line Width/Stroke” is at “1”, and that the “Zoom” bullet in the Ellipse Controls is ticked. Make your Design Trace color red and your background color black. Your Parameters window should be identical in all respects to the one shown below. (Note: Although it isn't critical, if you want your “Roy G. Biv” rainbow color choices for red, orange, yellow, green, blue, indigo, and violet to perfectly match those shown in the later images for this tutorial, select them according to the color windows below.)

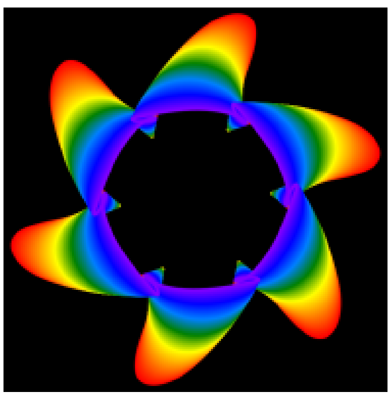


Press the “Draw” button for a single red Design Trace. Change the Design Trace color to orange and increment the Shift Lever 5 counts to “45”. Press “Draw”. Now press the “Undo” button to return to the single red Trace. Enter “10” in the Morph Number field and press Draw. Observe that there are noticeable spaces between the 11 Design Traces. Undo all 11 Traces back to a blank, black Paper Space. Change the Design Trace color back to red, return the Shift Lever to “40”, and change the “Line Width/Stroke” to “4”. Press “Draw” to obtain a single wide red Trace. Now change the Design Trace color to orange, increment the Shift Lever to “45”, enter “10” in

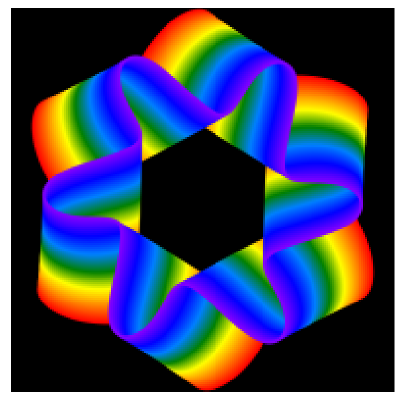
the Morph Number field, and press "Draw". Now the color morph between red and orange is very smooth, with little if any spacing between the Traces. If we had left the Line Width at "1", a much larger Morph Number would have been needed to obtain the same appearance.

Experimentation is often needed to allow us to choose the best Line Width for the effect we are trying to obtain. Narrow Line Widths produce sharp edges, especially in combination with "Fine" sampling. They are usually preferable for lacy, net-like or meshed-look Designs. Closely-spaced narrow Line Widths also tend to produce the best moiré effects. Wider, bolder Line Widths are often better for color morphs and for very large Designs, as well as in combination with narrow Traces to obtain the "ribbon" effect mentioned earlier. For completed, wide-Trace Design Suites, you will sometimes be pleasantly surprised by the results of ticking the "Dots" Line Type bullet. You will also find that generating wide-Trace Design Suites in combination with "Fine" sampling will affect the appearance of the Dots option.

Change the Design Trace color to yellow, increment the Shift Lever to "50", enter "10" in the Morph Number field, and press "Draw". Continue along these same lines with 5-count Shift Lever increments and 10-increment color morphs to green, blue, indigo, and violet, for the 61-Trace Design Suite shown at the left below.



Return the Design Trace color to red, return the Shift Lever to "40", and undo 61 Traces. You should be back to a blank, black Paper Space. Change the Left Pen Arm Peg Hole to "D", change the Right Pen Arm Peg Hole to "K", and press "Draw" for a single wide red Trace. Change both Peg Hole selections downward one bullet, to "E" and "L". Change the Trace color to orange, enter "10" in the Morph Number field, and press "Draw". Carry on to in the same manner to obtain the Suite shown at right.



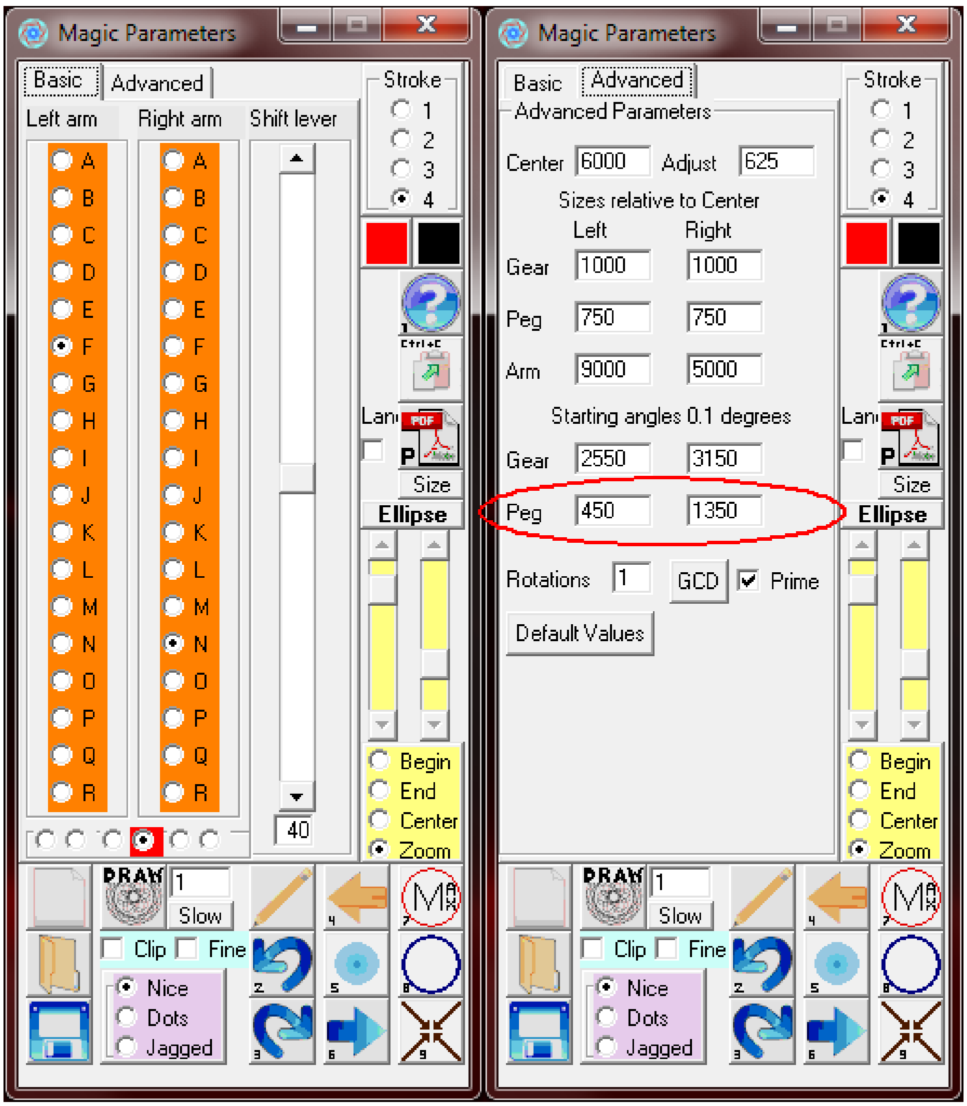
Now stop to reflect on some of the properties of the two Design Suites that you have just generated. In the first Suite, you used the Shift Lever to allow similar Design Trace shapes to be morphed inward, although the shapes became less similar as the Suite progressed. If you had left the Shift Lever alone and instead zoomed Ellipse size uniformly smaller at each step, all of the Design Traces in the Suite would have had an identical shape, although they would have been smaller in size as the Suite progressed. You actually used this morphing technique in an earlier exercise, though only between blue and red Trace colors and max and min Ellipse sizes.

In the second Design Suite, you used changes to the lengths of the Pen Arms to rotate similar Design Trace shapes to the right. However, no two Traces in the Suite had an identical size and shape. If you had carefully incremented Ellipse size outward, along with the Pen Arm changes, you might have obtained a uniform size for the rotated Traces, but still not a uniform shape. You can verify this visually by considering the first (red) and last (violet) Traces in the Suite. The "tips" of the red Trace slant to the right, whereas the tips of the violet Trace slant to the left.

Clearly it would be good to have a method of rotating identically-shaped Design Traces around a common center-point, with the rotated Traces having either an identical or an incremented size. This can't be accomplished using the controls discussed thus far, but the emulator does provide a way in which such rotations can be effected. Recall the 6-inch Center Gear on the physical Magic Designer. Imagine that the Center Gear has a firmly mounted paper disc, on which has been drawn a single Design Trace. Because the Center Gear is always meshed with the planetary Gears, no single Design Trace can be exactly duplicated at a new rotational angle (let's not argue about rotating the paper disc). It is hypothetically true that with enough effort, the Center

Gear might be removed from the metal base, rotated somewhat, and re-meshed with the planetary Gears, which would allow us to produce identical Design Traces at new rotational angles. It is also true that the two planetary Gears might be removed, rotated the same amount and direction, and re-meshed with the Center Gear. This would also allow us to duplicate identical Designs at different rotational angles. Neither of these approaches is practical for the real-world mechanical Magic Designer, but it turns out that the emulator *can* handle the second approach. That is, the emulator will allow the two planetary Gears to be "rotated" between Design Traces, independently of the Center Gear, which in turn will effectively allow us to "rotate" a given Design Trace as much as we like, without changing its size, shape, Line Width, color, and center-point (unless we want to).

Undo any Design Traces that you have in your Paper Space, click the Max Circle Ellipse button, and ensure that all of your Basic and Advanced Tab settings match those shown below. Be aware that pressing the "Default Values" button on the Advanced Tab will alter some Basic Tab settings, which you will then need to correct.



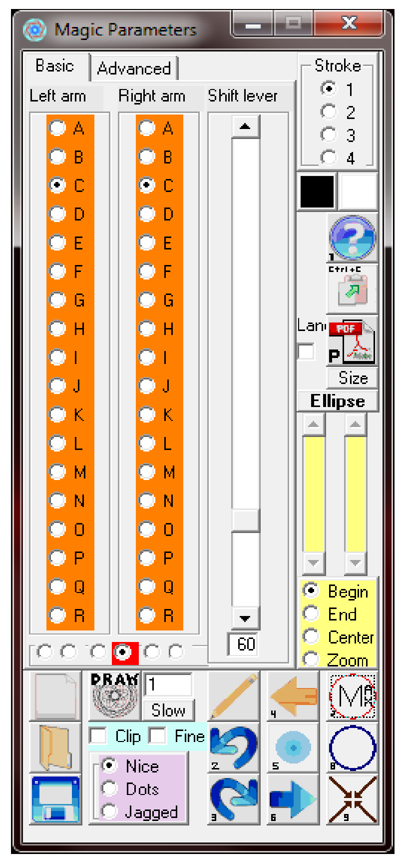
Press "Draw" to obtain a single wide red Design Trace. Note the Gear Peg polar angles circled in red. Realize that if you increment (or decrement) both of these values by the same amount, you will effectively be rotating both of the planetary Gears independently of the Center Gear. Remember that the angular values listed are to the nearest tenth of a degree, so the actual values in the fields are 45.0º and 135.0º. Add 30º (300) to each field (for values of 750 and 1650, respectively) and press the "Draw" button. You will now have a second red Trace, identical to the first in all respects except for a new rotational angle.

However, that angle is *not* 30º. Because the current gear ratio is 6-to-1, the Design Trace has only rotated 5º. It follows that for any desired angle of Design Trace rotation, the Gear Pegs must be rotated by six times as much. For example, if you want your next Trace to be 10º from the one that you just generated, you will need to increment both Gear Peg angle values by 60º (600). Do this for both values (to 1350 and 2250, respectively), and press "Draw". You will see that the new rotation is double the last, producing a 10º rotation instead of a 5º rotation. Now add 100º (1000) to each Gear Peg angle value and press "Draw". Do that once more, and you will end up with Gear Peg angle values of 335.0º and 425.0º. Obviously you are not limited to Gear Peg angles of 360.0º. As long as you increment both fields by the same amount, and as long as you make no other changes, you will continue to generate identical Traces in a clockwise, or "east" direction.

You can also *decrement* both Gear Peg angles by an identical amount, to rotate identical Design Traces counter-clockwise, or “west”, but you cannot decrease the Peg angle values below 0º without confusing the emulator. You can't enter “negative” degree values, and “toggling” a 0º value to 360º as you pass through it just won't work. In terms of polar coordinate angles, for example, decreasing 30º from a starting point of 10º yields the perfectly equivalent angle of 340º, which is 20º less than 360º, but if you change a Gear Peg angle from 10º to 340º, the emulator will simply think that you want to *increase* the angle by 330º in a clockwise direction.

However, it *is* possible to make large Gear Peg angle rotations in a counter-clockwise direction. The trick is to begin with adequately large Peg angle values, so that you don't run out of “overhead” and run the angles through 0º as you decrease them. With a little calculation you can increase the Peg angles just so, to obtain the same Trace position that existed before the angles were increased. For each full rotation of a six-sided Design, for example, an increased Peg angle value of 6 x 360.0º (21600) will be required.

You may find that you prefer eastward rotation, since westward rotation can be more confusing, but both approaches are useful. One very handy use of rotation is to position your initial Design Trace in a certain orientation. Whether your first Trace is symmetrical or asymmetrical, and six-sided or otherwise, you may want it to be aligned vertically or horizontally in some definite way. Rotation allows you to make that happen.



Experiment with different rotational values in both directions. When you are certain that you have a firm grasp of the process, click the Default Values button on the Advanced Tab, which will reset all of the Advanced Tab data fields and take you to the Basic Tab. You will also find that the Pen Arms, Shift Lever, Stroke/Line Width, and Design Trace color have been reset to their program start-up values. Had “Clip” or “Fine” been checked, they would also now be cleared, and any smaller Ellipse will now be maximized. The only Basic Tab controls not affected by the Advanced Tab Default Values button are Line Type, background color, and the previously-selected Ellipse Controls bullet. It follows that whenever you are in the middle of building a complex Design Suite, you will probably want to avoid clicking the Default Values button. For the next part of the tutorial though, we will want *all* of the Basic Tab controls (as well as the Advanced Tab controls) returned to their start-up default values, as depicted to the right, so click the “New/Start Over” button, verify that your Line Type is “Nice”, and select the “Begin” bullet in the Ellipse Controls.

Up to this point in the tutorial, we haven't closely examined the sophisticated features of the Ellipse Controls. We've begun all of our exercises with maximized, centered, circular Ellipses, and although we have done a bit of Ellipse “zooming”, all the way down to minimum size, we haven't explored non-circular Ellipses, center-point re-positioning, incremented Ellipse sizing, or off-paper, “negative” Ellipses. As your proficiency with Magic Designs progresses, you will want to have a mastery of these things, and that means you will need to become more familiar with the features of the Ellipse Controls.

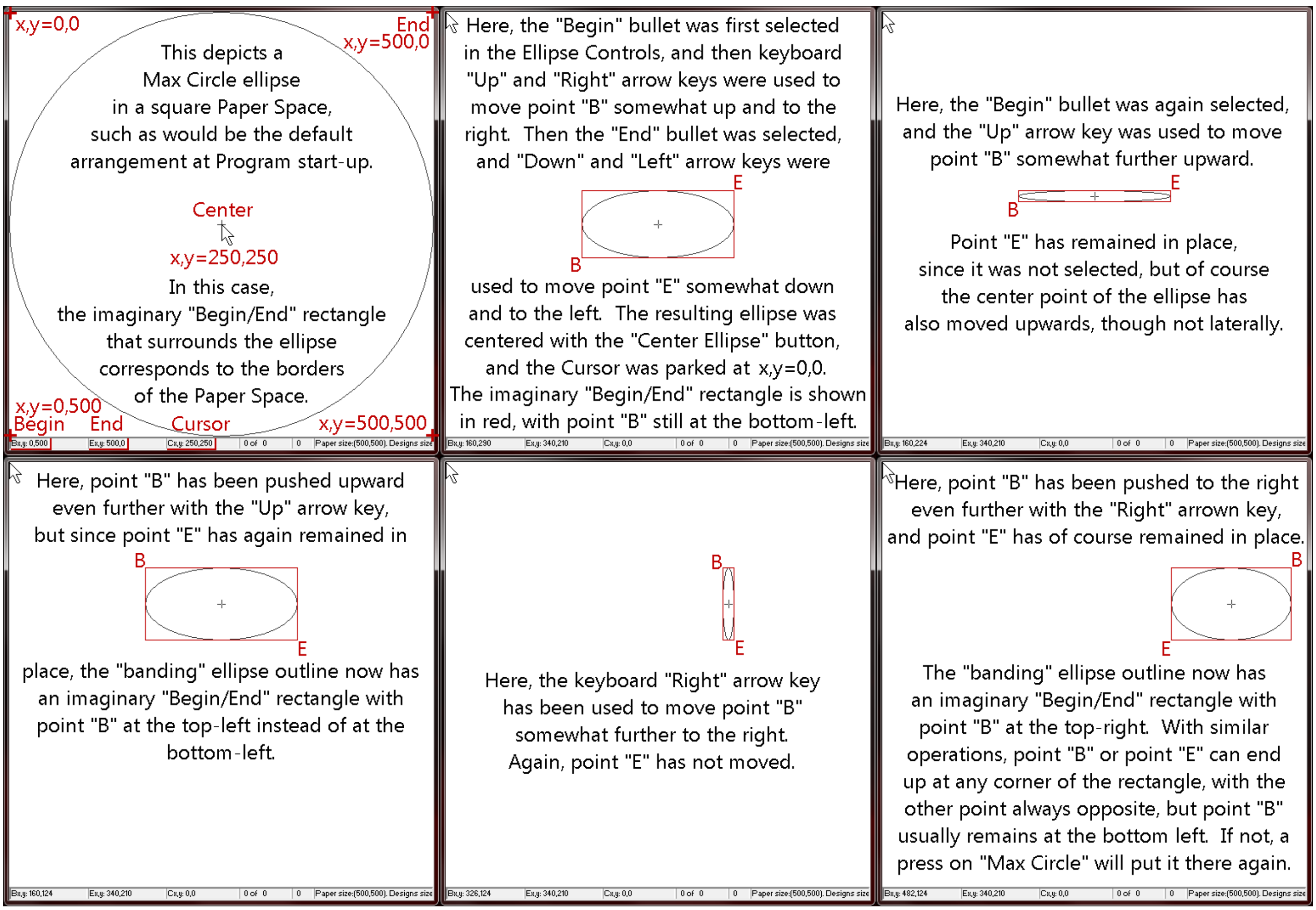
“Circles” are merely a special category of “Ellipses”, just as “squares” are a special category of “rectangles”. Where the Magic Designer is concerned, Ellipses may be either circular or “ellipsoidal”, and Design Traces can be generated based on both types. As a matter of convenience, the term “ellipsoid” is used rather loosely here to refer to two-dimensional, elongated or “oval” shapes, and not to the three-dimensional solids that the term actually refers to (as a mathematician might inform you).

Although most of your Magic Designs will probably be based on circular Ellipses, you will not want to ignore

the possibilities of ellipsoids. As you may know, ellipsoids have many special properties, giving rise to many special uses. For example, every ellipsoid has both a center-point and two “focal points”, all located along its “major axis”, which can be thought of as its longer “diameter”. Future revisions of the Magic Designer emulator may make some use of ellipsoidal focal points, but for now you will only need to be aware of the major and minor axes. If you want to learn more about ellipses and ellipsoids, a fair place to start is Wikipedia.

With the “Begin” bullet checked, hover your mouse cursor somewhere in the bottom-left corner of the Paper Space. Do a couple of left-clicks at slightly different locations, and then hold the click and move the mouse around, observing the effects on the Ellipse. While dragging the mouse, notice that the “B” readout is identical to that of the cursor “C” readout. Now click the “End” bullet in the Ellipse Controls. Hover your mouse at the top-right corner of the Paper Space and perform similar actions, noting that the “E” readout now follows “C”.

The Ellipse “Begin” and “End” points are at opposite corners of an imaginary rectangle surrounding the Ellipse. Either of these points can be precisely positioned, either by your mouse or by your keyboard arrow keys. Study the explanatory images below, and imitate the actions depicted. You don't need to make your Paper Space dimensions match those shown in the images, but of course you can if you want. One of the images refers to the “Center Ellipse” button, which is the button at the bottom-right of the Basic Tab.

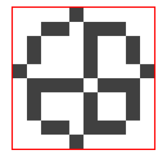


Now select the “Center” bullet in the Ellipse Controls. Click a few places in the Paper Space, and then hold the click and move the mouse around, observing the “C” readout. Also be certain to move the edges of the Ellipse beyond the left and top edges of the Paper Space, observing the “B”, “E”, and “C” readouts. You will see that their “x” and/or “y” values go negative as appropriate, since the top-left corner of the Paper Space is the measurement “origin” point of x,y=0,0 pixels.

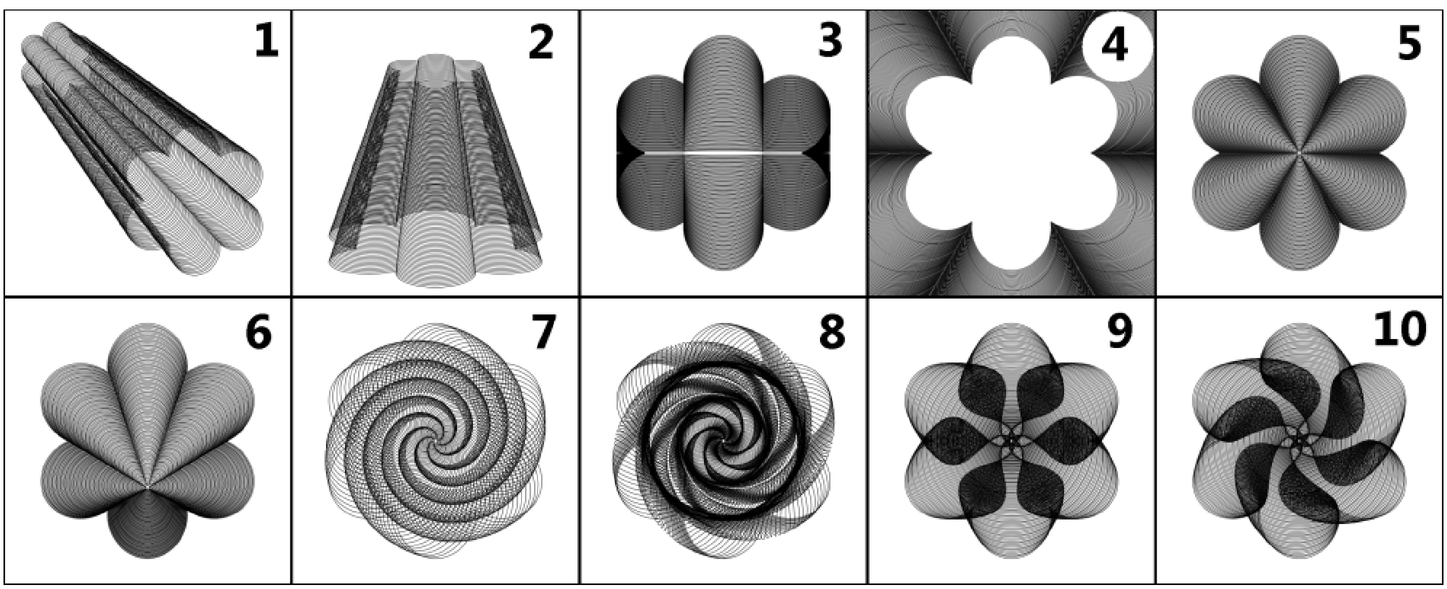
With a combination of Begin, End, and Center maneuvers, using either your mouse or your arrow keys, you can precisely size, shape, and position any Ellipse. As you already know, when you “zoom” an Ellipse you will only change its proportional size, not its shape or its center-point. As long as “Zoom” is ticked, shape and center point can't even be changed *accidentally*. That's one reason why this tutorial has had you select the “Zoom” bullet so often. For the other reason, select the “Zoom” bullet and click inside the Paper Space. See? Nothing happens. The “safest” bullet to leave selected is “Zoom”. Even if you accidentally hit an arrow key, correction will be easy.

Spend a few moments making Ellipses of different sizes, shapes, and positions. For each Ellipse, click the “Draw” button, which will generate the default 6-sided “clover” Design Trace. Note how the Trace is “squeezed” or “flattened” in “vertical” or “horizontal” ellipsoidal Ellipses. After making a couple of ellipsoidal Ellipses, also click the “Minimized Circle Ellipse” button, which is the second button up from the bottom-right on the Basic Tab. In one quick step, this button converts any ellipsoidal Ellipse into a circular Ellipse, by making the diameter of the circle equal to the minor axis dimension of the ellipsoid.

Incidentally, the minimum Ellipse dimension for which a Design Trace can be generated is 10 pixels, which is the diameter of a circular Ellipse that has been zoomed down to minimum size. To the right you will see one that has been “blown up” with graphics software. If you attempt to generate a Design for an Ellipse that has a dimension smaller than 10 pixels, the emulator will return the error message, “The ellipse is too small”. With Begin and End it is possible to shrink an Ellipse smaller, even to zero pixels, but the emulator will not be happy about that, and it may crash.



Now contemplate the two rows of Design Suites below, and see if you can suss out how each Suite was made. Clear your Paper Space and see if you can generate a reasonable imitation of each one. Begin each Suite from the program start-up default settings, using the six-sided clover pattern. You will not need to adjust either the Pen Arms or the Shift Lever to make any of the Suites, and obviously all will be made using a black Trace color and a Stroke/Line Width of “1”. A Morph Number of 100 is used for all but #8, for which 200 will work better.



#1. A circular Ellipse with a diameter about one-third the width of the Paper Space was positioned at the upper-left corner, where a clover was drawn. The Ellipse was then moved to the bottom-right corner and enlarged to about two-thirds the width of the Paper Space, where another clover was drawn with a Morph Number of 100. As is the case for any morph between two Design Traces, one of the Ellipses could also have been ellipsoidal, and/or the two Trace shapes could have been different, and/or the starting and ending Trace colors could have

been different, and/or the second Trace could have been rotated, etc. A wide Line Width might also have been used, which would have tended to blend the 100 morph intervals into a more "solid"-looking Design Suite.

#2. This is very much like #1, but with a morph between two ellipsoidal Ellipses. The major axis of the starting Ellipse, at the bottom, was made to equal the width of the Paper Space. After the starting clover was drawn, the center of the Ellipse was moved straight upward, close to the top of the Paper Space, where the Ellipse was made about half the width of the Paper Space. There, a clover was drawn with a 100-interval morph.

#3. Starting with a max circle Ellipse, a clover was drawn. The Ellipse was made ellipsoidal and vertically squeezed down to a minor axis dimension of 10 pixels. The major axis was made the same width as the Paper Space, so that it would match the diameter of the circular Ellipse. The center of the ellipsoidal Ellipse was positioned at the center of the Paper Space, where a clover was drawn with a 100-interval morph.

#4. Starting with a max circle Ellipse, a clover was drawn. The Ellipse was then zoomed outward, far beyond the borders of the Paper Space, where a clover was drawn with a 100-interval morph.

#5. Starting with a max circle Ellipse, a clover was drawn. The Ellipse was zoomed down to its minimum size, where a clover was drawn with a 100-interval morph.

#6. Starting with a max circle Ellipse, a clover was drawn. The Ellipse was zoomed down to its minimum size, and then its center-point was moved straight downward to a point about one-third the height of the Paper Space, where a clover was drawn with a 100-interval morph.

#7. Starting with a max circle Ellipse, a clover was drawn. The Ellipse was zoomed down to its minimum size. On the Advanced Tab, the Gear Peg angles were both increased by a count of 21600, which made the clover rotate by 360º during the course of the 100-interval morph. The reduction in Ellipse size and the rotation of the Design Traces were linear, so an Archimedean spiral was produced, with evenly-spaced distances between the spiral arms, except where they compress at the center. Virtually any Design Trace can be spiraled in this way.

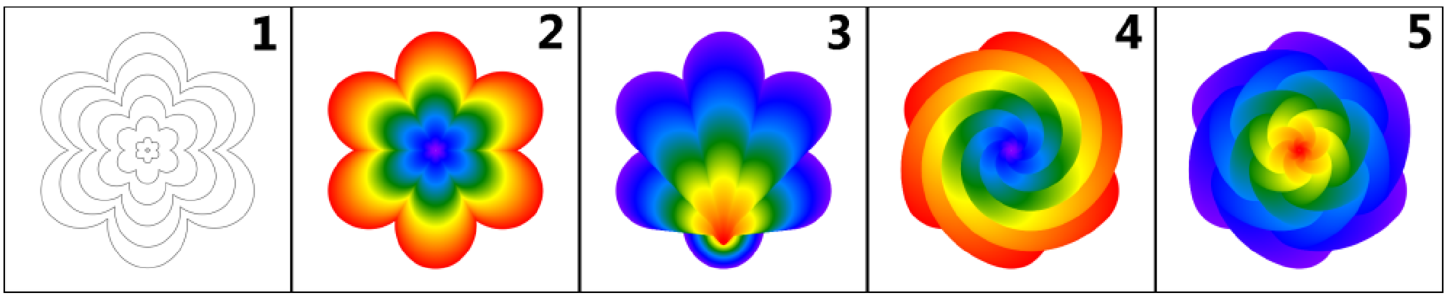
#8. High marks if you got this one right. It was set up just like #7, but an additional count of 10000 was added to the right Gear Peg angle before the Draw button was pressed. Nobody ever said that the two Gear Peg angles always have to be incremented by the same amount for a morph. Kind of sneaky, yes, but you had a clue, because obviously the Suite required rotation, just not a *simple* rotation like #7. Give it a few more tries, to see the effects of adding even higher counts to the right Gear Peg angle, as well as higher Morph intervals than 200.

#9. *Extremely* high marks for this one. Starting with a max circle Ellipse, a clover was drawn. The Ellipse was zoomed down to its minimum size. On the Advanced Tab, the Left planetary Gear angle was changed to 0º, and the Right planetary Gear angle was changed to 18º. Nobody ever said that *only* Gear Peg angles can be morphed. Okay, there was probably no way you could have gotten this one, but you might have come close, since obviously no rotation was involved, meaning that something *else* on the Advanced Tab must have been changed. Which is precisely the point; *everything* on the Advanced Tab can be changed for a morph, except, as previously mentioned, gear ratios, unless the changes call for an impossible Design Trace to be generated. Try this one again, too. Start with 0º for the left Gear and 10º for the right, then increase the right in 10-100º steps.

#10. No mystery for this one, at least not anymore. It was set up just like #9, but a rotation of 60º was added.
All of these "single-color" Design Suites were morphed between only two Design Traces, one at the start of the morph and one at the end. Nevertheless, they are reasonably well-defined Design Suites, because a narrow Line Width was used along with a small enough Morph Number to leave the Suites with a "netted" or "meshed" look. If we were to re-generate these Design Suites with a wider Stroke and with a larger Morph Number, they would all become less defined. At some point, each would become a solid "blob" of a single color, with no

discernible pattern at all, other than an outline. This condition wouldn't even be helped very much by having a different color for the ending Design Trace. If we want to generate Design Suites that are similar to those we just saw, but with a “solid” appearance instead of a “meshed” one, we need to have a way of *adding* definition. One way to accomplish this is by using more than just two color increments between the starting and final Design Traces, and to do that uniformly, we will need to have a way of determining where those increments should begin and end. This is where the “B” and “E” readouts can really be useful.

Consider Design Suite #1 below, which consists of seven Design Traces of an evenly-spaced, decreasing size. The outermost Trace is our familiar, start-up-defaults-value, six-side clover. For the other six Traces, the starting max circle Ellipse was simply reduced by six even intervals, or actually five, since the last reduction hit the 10-pixel Ellipse limit before it was quite completed. However, close enough for our purposes. All five Design Suites below were generated in the 560-pixel-square Paper Space that we have used throughout the tutorial, so if you want to follow along, be certain that your Paper Space is sized accordingly.



The Trace intervals in Suite #1, or rather the Ellipse intervals from which those Traces were generated, form the basis for the intervals in all of the other four Suites. Since we have begun with a max circle Ellipse in a 560-pixel Paper Space, the initial “B” reading in the Status Bar is “Bx,y: 0,560”, and the initial “E” reading in the Status Bar is “Ex,y: 560,0”. We can watch either of these two readouts as we zoom the Ellipse down to produce the intervals.

Since the max circle Ellipse has a diameter of 560 pixels, and since we can zoom it down to a diameter of 10 pixels, we have a 550-pixel “diameter reduction range”. If we want six perfect Ellipse reductions to the tiny one, that would be 550 divided by 6 = 91.666... pixels per step. Since we don't care that much about precision, at least not this time, we are just arbitrarily going to reduce the Ellipse diameter by 100 pixels per step. Bear in mind that during a zoom, both the bottom of the Ellipse, where “B” is located, and the top of the Ellipse, where “E” is located, are going to change by the same number of pixels. So for each interval we can watch either readout, and just zoom the Ellipse with our arrow keys until that readout has changed by an even 50 counts in both its “x” and “y” values. Let's watch “B”. From the initial “B” reading of 0,560 we will go to:

50,510
100,460
150,410
200,360
250,410 and
275,285 (where we will hit the minimum Ellipse size limit).

Zoom your max circle Ellipse down to the first interval. Notice that you can stop at either 50,511 or 50,510. That's because the Ellipse pixels actually zigzag in one-pixel increments during the reduction. Since we started with “even” values of 0 and 560, we want each step to have even values for both x and y. Zoom the Ellipse down to each remaining interval, or if you're lazy just max your Ellipse and go on to the instructions below. Each Design Suite will use a Stroke/Line Width of “4”.

Suite 2: Select red for your Trace color. Draw the clover. Zoom the Ellipse down to the first interval, change to orange, enter a Morph number of 100, and click Draw. Zoom to the next interval, change to yellow, enter a Morph number of 100, and click Draw. Carry on likewise for green, blue, indigo, and violet.

Suite 3: This one is a bit more work, so it's easier to muck up. Select violet and draw the first clover. Zoom the Ellipse down to the first interval, change to indigo, and then select the Center bullet in the Ellipse Controls. The center of the Paper Space is x,y: 280,280, so watch the "C" readout as you position your mouse cursor for a reading of Cx,y: 280,310. Hold your mouse steady and click it to snap the Ellipse to this new center-point, or just click and drag the Ellipse to the new point. Change the bullet back to Zoom. Enter 100 in the Morph Number field and click Draw. Now click the Center Ellipse button at the bottom-right of the Basic Tab.

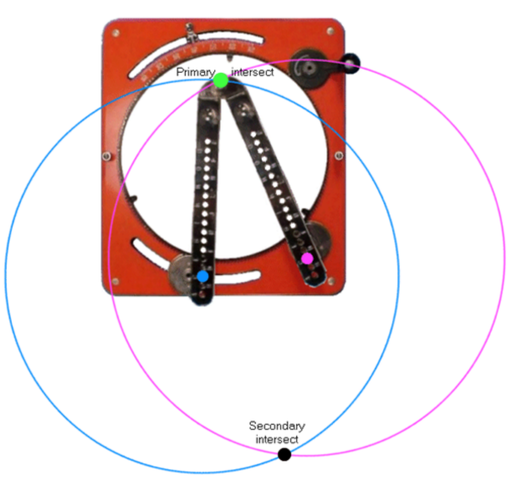
Before going on to the second step, consider what you have done for the first. We are using a zoom interval technique that relies on readout "B", based on even increments from a "starting" readout for which the Ellipse has a definite center-point. Before each reduction of the Ellipse, therefore, we will need to have the Ellipse back at that same center-point. Before each morph, however, we will need to have the center-point at a progressively lower location, at 30-pixel intervals in this case. We first moved the center-point down to 310. Next we will go to 340, 370, 400, 430, and 460. We will also need to keep track of the Ellipse Controls bullets.

Zoom the Ellipse down to the next interval, change to blue, and select the Center bullet. Center the Ellipse at 280,340. Change the bullet back to Zoom. Enter a morph number of 100 and click Draw. Click the Center Ellipse button. Now just carry on in the same way for green, yellow, orange, and red. No problem, right?

Suite 4: Draw the red clover. Zoom the Ellipse down to the first interval. Change to orange. On the Advanced Tab, add a count of 3600 to both Gear Peg angle values. This will give you a rotation of 360º divided by 6 = 60º. Enter a Morph Number value of 100 and click Draw. Zoom the Ellipse down to the next interval. Change to yellow. Add another count of 3600 to both Gear Peg angles. Enter a Morph Number value of 100 and click Draw. Carry on for green, blue, indigo, and violet.

Suite 5: If you just completed Suite 4 you will need to click the Default Values button and reset the Stroke/Line Width to "4". Also be certain that the Ellipse Controls Zoom bullet is selected. Change the Design Trace color to violet and draw the clover. Zoom the Ellipse down to the first interval. Change to indigo. On the Advanced Tab, add a count of 3600 to both Gear Peg angle values. Enter a Morph Number value of 100 and click Draw.

Zoom the Ellipse down to the next interval. Change to blue. On the Advanced Tab, *subtract* a count of 3600 from both Gear Peg angle values. Enter a Morph Number value of 100 and click Draw. Now carry on, adding 60º for green, subtracting 60º for yellow, adding 60º for orange, and subtracting 60º for red.



The only setting of the emulator not yet discussed is the 'Prime' tick box, located just to the right of the GCD button on the Advanced Tab. The emulator calculates each point of a Design Trace based upon the intersection of two hypothetical circles. In the illustration to the left, the Left Pen Arm would pivot on the Left Gear Peg to form the blue circle, the Right Pen Arm would would pivot on the Right Gear Peg to form the pink circle, and the primary intersect would be at the green dot, representing the current point of a Design Trace with 'Prime' ticked, the usual setting for most Designs. However, there is a secondary intersect of the two circles at the black dot, representing the current point of a Design Trace when 'Prime' is *not* ticked, which can be useful for making patterns in the outer areas of large Paper Spaces. Morphing Designs between the two intersects is not allowed.